JC17 Rec'd PCT/PTO 19 JUN 2001

FORM PTO-1390 (REV. 11-2000) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY 'S DOCKET NUMBER: Mic.6287

U.S. APPLICATION NO (If known, see 37 CFR 1 5: 09/868538

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/EP99/10045	17 December 1999	19 December 1998

TITLE OF INVENTION
CAPACITIVE MAGNETIC FIELD SENSOR

APPLICANT(S) FOR DO/EO/US
Günter Igel, Ulrich Sieben, Jürgen Giehl

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [X] This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. [X] The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [X] is attached hereto (required only if not communicated by the International Bureau).
   b. [ ] has been communicated by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [X] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. [X] is attached hereto.
   b. [ ] has been previously submitted under 35 U.S.C. 154(d)(4).
7. [ ] Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are attached hereto (required only if not communicated by the International Bureau).
   b. [ ] have been communicated by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. [ ] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [X] An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. [X] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [X] A FIRST preliminary amendment.
14. [ ] A SECOND or SUBSEQUENT preliminary amendment.
15. [X] A substitute specification.
16. [ ] A change of power of attorney and/or address letter.
17. [ ] A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. [ ] A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. [ ] A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. [X] Other items or information:
   - Copy of International Preliminary Examination Report in German

JC18 Rec'd PCT/PTO 1 9 JUN 2001

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
09/868538	PCT/EP99/10045	Mic.6287

21. [X] The following fees are submitted:

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):

	CALCULATIONS	PTO USE ONLY
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1000.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$860.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$710.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$690.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 860.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [X] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$ 130.00	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	$	
Total claims	14 -20 =	0	x **$18.00**	$	
Independent claims	1 -3 =	0	x **$80.00**	$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$270.00**	$	
TOTAL OF ABOVE CALCULATIONS =				$ 990.00	
[ ] Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. +				$	
SUBTOTAL =				$ 990.00	
Processing fee of **$130.00** for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				$	
TOTAL NATIONAL FEE =				$ 990.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$	
TOTAL FEES ENCLOSED =				$ 990.00	
				Amount to be refunded:	$
				charged:	$

a. [X] A check in the amount of $ 990.00 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. ____________ in the amount of $ __________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 19-0079 . A duplicate copy of this sheet is enclosed.

d. [ ] Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO.

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35,305
REGISTRATION NUMBER

09/868538

Micronas.6287

JC18 Rec'd PCT/PTO 19 JUN 2001

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANT: Igel et al.

GROUP: Not yet assigned

INTERNATIONAL APPLN. NO.: PCT/EP99/10045

EXAMINER: Not yet assigned

SERIAL NO: Not yet assigned

INTERNATIONAL FILING DATE: 17 December 1999

FOR: CAPACITIVE MAGNETIC FIELD SENSOR

FIRST PRELIMINARY AMENDMENT

Entry of this preliminary amendment is respectfully requested.

Table of Contents:

Preliminary to calculation of the filing fee, please amend the above-identified application as follows:

Marked-up copy of the specification

Description

Capacitive Magnetic Field Sensor

BACKGROUND OF THE INVENTION

The present invention relates to the field of magnetic field sensors, and in particular to the field of capacitive magnetic field sensors.

~~A plurality of m~~Magnetic field sensors ~~is known, which are~~ are often based on the Hall or magnetoresistive effect. These magnetic field sensors are extremely temperature dependent, and as a result ~~for this reason~~ they are not well suited for high-precision applications or else require ~~very~~ expensive electronic or electrical temperature corrections.

~~Furthermore, c~~Capacitive sensors are customarily used for measuring pressures or accelerations. These generally prove to be mechanically very stable and have small exterior dimensions.

There is a need for ~~It is the object of the invention to create~~ a magnetic field sensor which depends less on interfering temperature effects.

SUMMARY OF THE INVENTION

~~According to the invention, this object is achieved by the characteristics specified in Claim 1.~~

~~The inventive~~ A capacitive magnetic field sensor includes ~~has~~ two electrodes, which are spaced apart from one another and which form a measurement capacitance. The first electrode is situated on a first substrate body, and the second electrode on a second substrate body. The second substrate body is designed as a deformable membrane in the vicinity of the second electrode, and has a magnetic body, which is rigidly connected to the membrane and to the second electrode. If the

magnetic body is caused to change its position by an external magnetic field, this change of position is imparted to the membrane and to the second electrode through the rigid connection between the magnetic body, the membrane, and this second electrode. The distance between the two electrodes is thus changed, so that the measurement capacitance of the sensor changes as a function of the external magnetic field. This yields a reliable measurement of the magnetic field strength through the change of the capacitive properties of the sensor.

This type of structure of the magnetic field sensor significantly reduces its temperature dependence, since the elastic properties of the capacitive sensor ~~here~~ are much less subject to temperature dependencies than the prior art sensors based on the Hall or magnetoresistive effect. Furthermore, the inventive capacitive magnetic field sensor proves to be mechanically very stable, not prone to trouble, and also has small external dimensions.

~~Advantageous designs of the capacitive magnetic field sensor are presented in the subclaims.~~ ~~In particular, i~~It proves to be especially advantageous to situate the second electrode and the magnetic body on different sides of the membrane. This excludes a mechanical or electrical direct effect of the magnetic body through the second electrode due to the membrane which separates them. ~~Also, t~~This ~~advantageous~~ arrangement also proves to facilitate manufacturability ~~make manufacture~~ of the sensor ~~much easier~~, since the two sides of the membrane can be subjected to different production processes, which cannot mutually influence or disturb one another through their mechanical separation by the membrane.

The production process for the capacitive magnetic field sensor is thus simplified and made economical.

The magnetic body can be ~~advantageously is~~ constructed as a thin, flat layer, whose surface is joined to the membrane. This surface connection produces a very rigid arrangement of a layer-

like magnetic body, the membrane, and the second electrode. This rigid structure of the various materials ~~markedly~~ reduces the mechanical temperature dependence of the properties of the capacitive sensor.

Furthermore, this layer can be applied ~~very~~ easily in the manner of an electrochemical deposition process, comparable to the process for applying printed circuits to circuit boards. This makes it possible to produce a layer with a defined thickness ~~very easily~~, and assures that a defined quantity of magnetic material is used for the magnetic body, a quantity which is sufficient to influence the position of the magnetic body adequately through the action of an external magnetic field and thus to determine the magnetic field strength. The use of ferromagnetic material has ~~here~~ proven to be especially beneficial. Such material can be applied ~~very~~ simply and securely by appropriately designing the deposition method.

According to a preferred embodiment of the capacitive magnetic field sensor, an electronic arrangement for processing the measurement signals is integrated into at least one of the substrate bodies. This integration takes the form of an integrated circuit. This assures that, in addition to the ~~extremely~~ compact structure of the capacitive sensor, an electronic ~~very advantageous~~ arrangement for evaluating the measurement signals is also present, which is ~~especially~~ characterized by low loss power in the path from the actual capacitive magnetic field sensor to the arrangement for processing the measurement signals and ~~thereby also has~~ an especially good signal-to-noise ratio, and thus~~thereby~~ provides a ~~very~~ differentiated evaluation and representation of the magnetic field strength. ~~This inventive~~ The capacitive magnetic field sensor thus proves to be ~~an extremely~~ a compact and reliable magnetic field sensor with high resolution. Such sensors are especially important in the automobile industry, where ~~very~~ limited space is generally available.

The electronic arrangement for processing the measurement signal is preferably ~~is~~ situated in the first substrate body below the electrode that is affixed thereto. This structure in the mechanically rigid, immobile first substrate body also assures a mechanically trouble-free electronic arrangement for processing the measurement signals. This significantly extends the field of application of this capacitive magnetic field sensor, and makes it especially suitable for the automobile industry or the aircraft industry.

It is especially advantageous to divide the electronic arrangement for processing the measurement signals and to situate the parts separately in the two different substrate bodies. Here, too, the electronic arrangement is preferably ~~is~~ designed in the manner of an integrated circuit. Through this division, electronic functional groups such as amplifiers, evaluation units, or control units can be electronically decoupled from one another, and thus ~~a~~ cross talk from one functional group to the other functional group can be prevented. Precisely in the case of very weak signals with especially poor signal-to-noise ratio, very accurate measurement results for the field strength nevertheless can be calculated and displayed, since now this arrangement for processing the measurement signals markedly reduces any impairment of the measurement results due to cross talk between amplification, evaluation, etc.

It has proven especially suitable to design the capacitive magnetic field sensor so that at least one of the electrodes is formed by conductor tracks on the respective substrate, which are preferably ~~are~~ part of the electronic arrangement for processing the measurement signal. Through this design, the electrodes can be produced rather ~~very~~ simply, and their form and dimension can be specifically adapted to the particular requirements. This yields a ~~very~~ compact, ~~very~~ reliable, and high-resolution capacitive magnetic field sensor. When the conductor track of the electronic arrangement

is used both as an electrode and as an electronic element, it becomes possible to achieve a high degree of integration for the overall arrangement and to use this conductor track synergetically.

An especially advantageous capacitive magnetic field sensor has an electrode whose spatial structure makes it able to provide still more spatial resolution of the arrangement of the electrodes relative to one another, beyond their pure distance from one another. This makes it possible to show and make available to the user not only the pure magnetic field strength but also the orientation of the magnetic field or the time- or space-change of the magnetic field, by ~~means of~~ a space-resolving measurement. This aspect comes ~~especially~~ to bear when the two electrodes are not disposed parallel to one another through an external influence, e.g., the pattern of the magnetic field or the time- or space-change of the magnetic field, but rather are situated at an angle to one another and this angle changes through the flexible design of the membrane and/or the motion of the electrodes relative to one another. Such changes prove ~~very~~ useful to the user of the capacitive magnetic field sensor, since he obtains ~~further~~ additional information about the time or space behavior of the external magnetic field. Such information ~~especially~~ allows conclusions regarding the further actuation and/or amplification of the measurement signals. It has proven ~~especially~~ advantageous to dispose the electronic arrangement for the space-resolving processing of the measurement signals of the spatially structured electrode of the electronic arrangement for processing the measurement signals in one or in both substrates. Here, too, this arrangement proves to be especially advantageous both in terms of production engineering and as regards the compactness of the capacitive magnetic field sensor as well as regards its mechanical stability.

BRIEF DESCRIPTION OF THE DRAWING

The FIGURE illustrates a cross sectional of a capacitive magnetic field sensor~~An embodiment of the invention is shown in the drawing and will be described in more detail below~~.

DETAILED DESCRIPTION OF THE INVENTION

The FIGURE ~~Figure 1~~ schematically illustrates a ~~shows the structure of the~~ capacitive magnetic field sensor 1. The capacitive magnetic field sensor 1 includes ~~has~~ a first electrode 2, which is situated on a first substrate body 4. A second electrode 3 is associated with the first electrode 2, and is situated at a distance therefrom. It is affixed to a second substrate body 5. The second substrate body 5~~2~~ is designed as a membrane in the vicinity of the second electrode 3. In this way, the distance between the two electrodes 2 and 3 can change under the action of a force on the membrane, more or less depending on the type and hardness of the membrane. In this capacitive magnetic field sensor, a magnetic body 6 is situated on the backside of the membrane, that is on the side which faces away from the second electrode 3. Depending on an external magnetic field, said magnetic body applies a defined force on the membrane, and thus moves the membrane together with the second electrode 3, thereby changing the distance between the two electrodes 2 and 3. This change of distance causes a change in the capacitance of the arrangement consisting of the two electrodes 2 and 3. This change of capacitance is amplified and evaluated by an arrangement (not shown ~~here~~) for processing the measurement signals in the first substrate 4. The ~~inventively realized concept of the~~ capacitive magnetic field sensor 1 thus makes it possible to reliably measure the field strength of the external magnetic field ~~very reliably~~, without strong temperature dependencies.

What is claimed is:

~~List of Reference Symbols~~

~~1 Capacitive magnetic field sensor~~

~~2 First electrode~~

~~3 Second electrode~~

~~4 First substrate body~~

~~5 Second substrate body~~

~~6 Magnetic body~~

Clean Copy of the Specification
Following Entry of this Amendment

Description

Capacitive Magnetic Field Sensor

BACKGROUND OF THE INVENTION

The present invention relates to the field of magnetic field sensors, and in particular to the field of capacitive magnetic field sensors.

Magnetic field sensors are often based on the Hall or magnetoresistive effect. These magnetic field sensors are extremely temperature dependent, and as a result they are not well suited for high-precision applications or else require expensive electronic or electrical temperature corrections.

Capacitive sensors are customarily used for measuring pressures or accelerations. These generally prove to be mechanically very stable and have small exterior dimensions.

There is a need for a magnetic field sensor which depends less on interfering temperature effects.

SUMMARY OF THE INVENTION

A capacitive magnetic field sensor includes two electrodes, which are spaced apart from one another and which form a measurement capacitance. The first electrode is situated on a first substrate body, and the second electrode on a second substrate body. The second substrate body is designed as a deformable membrane in the vicinity of the second electrode, and has a magnetic body, which is rigidly connected to the membrane and to the second electrode. If the magnetic body is caused to change its position by an external magnetic field, this change of position is imparted to the membrane and to the second electrode through the rigid connection between the magnetic body,

the membrane, and this second electrode. The distance between the two electrodes is thus changed, so that the measurement capacitance of the sensor changes as a function of the external magnetic field. This yields a reliable measurement of the magnetic field strength through the change of the capacitive properties of the sensor.

This type of structure of the magnetic field sensor significantly reduces its temperature dependence, since the elastic properties of the capacitive sensor are much less subject to temperature dependencies than the prior art sensors based on the Hall or magnetoresistive effect. Furthermore, the inventive capacitive magnetic field sensor proves to be mechanically very stable, not prone to trouble, and also has small external dimensions.

It proves to be especially advantageous to situate the second electrode and the magnetic body on different sides of the membrane. This excludes a mechanical or electrical direct effect of the magnetic body through the second electrode due to the membrane which separates them. This arrangement also proves to facilitate manufacturability of the sensor, since the two sides of the membrane can be subjected to different production processes, which cannot mutually influence or disturb one another through their mechanical separation by the membrane. The production process for the capacitive magnetic field sensor is thus simplified and made economical.

The magnetic body can be constructed as a thin, flat layer, whose surface is joined to the membrane. This surface connection produces a very rigid arrangement of a layer-like magnetic body, the membrane, and the second electrode. This rigid structure of the various materials reduces the mechanical temperature dependence of the properties of the capacitive sensor.

Furthermore, this layer can be applied easily in the manner of an electrochemical deposition process, comparable to the process for applying printed circuits to circuit boards. This makes it possible to produce a layer with a defined thickness, and assures that a defined quantity of magnetic

material is used for the magnetic body, a quantity which is sufficient to influence the position of the magnetic body adequately through the action of an external magnetic field and thus to determine the magnetic field strength. The use of ferromagnetic material has proven to be especially beneficial. Such material can be applied simply and securely by appropriately designing the deposition method.

According to a preferred embodiment of the capacitive magnetic field sensor, an electronic arrangement for processing the measurement signals is integrated into at least one of the substrate bodies. This integration takes the form of an integrated circuit. This assures that, in addition to the compact structure of the capacitive sensor, an electronic arrangement for evaluating the measurement signals is also present, which is characterized by low loss power in the path from the actual capacitive magnetic field sensor to the arrangement for processing the measurement signals and an especially good signal-to-noise ratio, and thus provides a differentiated evaluation and representation of the magnetic field strength. The capacitive magnetic field sensor thus proves to be a compact and reliable magnetic field sensor with high resolution. Such sensors are especially important in the automobile industry, where limited space is generally available.

The electronic arrangement for processing the measurement signal is preferably situated in the first substrate body below the electrode that is affixed thereto. This structure in the mechanically rigid, immobile first substrate body also assures a mechanically trouble-free electronic arrangement for processing the measurement signals. This significantly extends the field of application of this capacitive magnetic field sensor, and makes it especially suitable for the automobile industry or the aircraft industry.

It is especially advantageous to divide the electronic arrangement for processing the measurement signals and to situate the parts separately in the two different substrate bodies. Here, too, the electronic arrangement is preferably designed in the manner of an integrated circuit.

Through this division, electronic functional groups such as amplifiers, evaluation units, or control units can be electronically decoupled from one another, and thus cross talk from one functional group to the other functional group can be prevented. Precisely in the case of very weak signals with especially poor signal-to-noise ratio, very accurate measurement results for the field strength nevertheless can be calculated and displayed, since now this arrangement for processing the measurement signals markedly reduces any impairment of the measurement results due to cross talk between amplification, evaluation, etc.

It has proven especially suitable to design the capacitive magnetic field sensor so that at least one of the electrodes is formed by conductor tracks on the respective substrate, which are preferably part of the electronic arrangement for processing the measurement signal. Through this design, the electrodes can be produced rather simply, and their form and dimension can be specifically adapted to the particular requirements. This yields a compact, reliable, and high-resolution capacitive magnetic field sensor. When the conductor track of the electronic arrangement is used both as an electrode and as an electronic element, it becomes possible to achieve a high degree of integration for the overall arrangement and to use this conductor track synergetically.

An especially advantageous capacitive magnetic field sensor has an electrode whose spatial structure makes it able to provide still more spatial resolution of the arrangement of the electrodes relative to one another, beyond their pure distance from one another. This makes it possible to show and make available to the user not only the pure magnetic field strength but also the orientation of the magnetic field or the time- or space-change of the magnetic field, by a space-resolving measurement. This aspect comes to bear when the two electrodes are not disposed parallel to one another through an external influence, e.g., the pattern of the magnetic field or the time- or space-change of the magnetic field, but rather are situated at an angle to one another and this angle changes

through the flexible design of the membrane and/or the motion of the electrodes relative to one another. Such changes prove useful to the user of the capacitive magnetic field sensor, since he obtains additional information about the time or space behavior of the external magnetic field. Such information allows conclusions regarding the further actuation and/or amplification of the measurement signals. It has proven advantageous to dispose the electronic arrangement for the space-resolving processing of the measurement signals of the spatially structured electrode of the electronic arrangement for processing the measurement signals in one or in both substrates. Here, too, this arrangement proves to be especially advantageous both in terms of production engineering and as regards the compactness of the capacitive magnetic field sensor as well as regards its mechanical stability.

BRIEF DESCRIPTION OF THE DRAWING

The FIGURE illustrates a cross sectional of a capacitive magnetic field sensor.

DETAILED DESCRIPTION OF THE INVENTION

The FIGURE schematically illustrates a capacitive magnetic field sensor 1. The capacitive magnetic field sensor 1 includes a first electrode 2, which is situated on a first substrate body 4. A second electrode 3 is associated with the first electrode 2, and is situated at a distance therefrom. It is affixed to a second substrate body 5. The second substrate body 5 is designed as a membrane in the vicinity of the second electrode 3. In this way, the distance between the two electrodes 2 and 3 can change under the action of a force on the membrane, more or less depending on the type and hardness of the membrane. In this capacitive magnetic field sensor, a magnetic body 6 is situated on the backside of the membrane, that is on the side which faces away from the second electrode 3.

Depending on an external magnetic field, said magnetic body applies a defined force on the membrane, and thus moves the membrane together with the second electrode 3, thereby changing the distance between the two electrodes 2 and 3. This change of distance causes a change in the capacitance of the arrangement consisting of the two electrodes 2 and 3. This change of capacitance is amplified and evaluated by an arrangement (not shown) for processing the measurement signals in the first substrate 4. The capacitive magnetic field sensor 1 thus makes it possible to reliably measure the field strength of the external magnetic field, without strong temperature dependencies.

What is claimed is:

Clean Copy of the Claims Following Entry of This Amendment

1. (amended) A capacitive sensor with a first electrode and a second electrode, which are spaced apart from one another and which form a measurement capacitance, such that the first electrode is situated on a first substrate body and the second electrode on a second substrate body, and the second substrate body is designed as a deformable membrane in the vicinity of the second electrode, characterized in that a magnetic body is disposed in the vicinity of the second electrode and the membrane, which magnetic body is connected to the membrane and to the second electrode in such a way that a change of position of the magnetic body, induced by an external magnetic field, will cause a change of position of the second electrode via the membrane, resulting in a capacitance change.

2.(amended) The capacitive sensor of claim 1, wherein the second electrode and the magnetic body are situated on opposite sides of the membrane.

3.(amended) The capacitive sensor of claim 2, wherein the magnetic body is formed as a thin layer.

4.(amended) The capacitive sensor of claim 3, wherein the magnetic body contains ferromagnetic material.

5.(amended) The capacitive sensor of claim 3, comprising an electronic arrangement for processing the measurement signals that is integrated into at least one of the substrate bodies.

6.(amended) The capacitive sensor of claim 5, wherein the electronic arrangement for processing the measurement signals is situated in the first substrate body below the electrode affixed thereon.

7.(amended) The capacitive sensor of claim 5, wherein a first part of the electronic arrangement for processing the measurement signals is situated in the first substrate body and a second part of the electronic arrangement for processing the measurement signals is situated in the second substrate body.

8.(amended) The capacitive sensor of claim 5, wherein the electronic arrangement for processing the measurement signals has elements to amplify the measurement signal.

9.(amended) The capacitive sensor of claim 5, wherein the electronic arrangement for processing the measurement signals has elements for applying a voltage signal across the first and second electrodes.

10.(amended) The capacitive sensor of claim 5, wherein at least one of the electrodes is formed as at least one conductor track.

11.(amended) The capacitive sensor of claim 10, wherein the conductor track is part of the electronic arrangement for processing the measurement signals.

12.(amended) The capacitive sensor of one of claim 11, wherein the first electrode is configured and arranged with respect to the second electrode to provide a space-resolving measurement.

13.(amended) The capacitive sensor of claim 12, wherein the first electrode has mutually parallel, strip-shaped elements.

14.(amended) The capacitive sensor of claim 13, wherein the electronic arrangement for processing the measurement signals processes the measurement signals to provide the space-resolving measurement.

REMARKS

Claims 1-14 have been amended. Claims 1-14 remain.

Examination on the merits is respectfully requested.

If a telephone interview could assist in the prosecution of this application, please call the undersigned attorney.

Respectfully submitted,

Patrick O'Shea

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VERSION WITH MARKINGS TO SHOW CHANGES MADE TO CLAIMS

1.(amended) A capacitive sensor [(1)] with a first electrode [(2)] and a second electrode[(3)], which are spaced apart from one another and which form a measurement capacitance, such that the first electrode[(2)] is situated on a first substrate body [(4)] and the second electrode [(3)] on a second substrate body [(5)], and the second substrate body [(5)] is designed as a deformable membrane in the vicinity of the second electrode [(3)], characterized in that a magnetic body [(6)] is disposed in the vicinity of the second electrode [(3)[and the membrane, which magnetic body is connected to the membrane and to the second electrode [(3)] in such a way that a change of position of the magnetic body [(6)], induced by an external magnetic field, will cause a change of position of the second electrode [(3)] via the membrane, resulting in a capacitance change.

2.(amended) The capacitive sensor of [C]claim 1, [characterized in that] wherein the second electrode [(3)] and the magnetic body [(6)] are situated on opposite sides of the membrane.

3.(amended) The capacitive sensor of claim 2, wherein [one of the preceding claims, characterized in that] the magnetic body [(6)] is formed as a thin layer.

4.(amended) The capacitive sensor of claim 3, wherein [one of the preceding claims, characterized in that] the magnetic body [(6)] contains ferromagnetic material.

5.(amended) The capacitive sensor of claim 3, comprising [one of the preceding claims, characterized in that] an electronic arrangement for processing the measurement signals that is integrated into at least one of the substrate bodies [(4, 5)].

6.(amended) The capacitive sensor of ~~C~~ claim 5, wherein [characterized in that] the electronic arrangement for processing the measurement signals is situated in the first substrate body below the electrode affixed thereon.

7.(amended) The capacitive sensor of ~~C~~claim 5, [characterized in that] wherein a first part of the electronic arrangement for processing the measurement signals is situated in the first substrate body [(4)] and a second part of the electronic arrangement for processing the measurement signals is situated in the second substrate body [(5)].

8.(amended) The capacitive sensor of ~~one of the Claims 5 to 7~~claim 5, [characterized in that] wherein the electronic arrangement for processing the measurement signals has elements to amplify the measurement signal.

9.(amended) The capacitive sensor of [one of the Claims 5 to 8, characterized in that] claim 5, wherein the electronic arrangement for processing the measurement signals has elements for [actuating the signal.]applying a voltage signal across the first and second electrodes.

10.(amended) The capacitive sensor of [one of the Claims 5 to 9, characterized in that] claim 5, wherein at least one of the electrodes is formed as [one or more]at least one conductor track[s].

11.(amended) The capacitive sensor of ~~C~~claim 10, [characterized in that] wherein the conductor track is part of the electronic arrangement for processing the measurement signals.

12.(amended) The capacitive sensor of one of claim 11, wherein [the preceding claims, characterized in that at least one]the first electrode [(2, 3) has a spatial structure for]is configured and arranged with respect to the second electrode to provide a space-resolving measurement.

13.(amended) The capacitive sensor of ~~C~~claim 12, [characterized in that] wherein the first electrode [(2, 3)] has mutually parallel, strip-shaped elements.

14.(amended) The capacitive sensor of ~~C~~claim [12 or] 13, [characterized in that] wherein the electronic arrangement for processing the measurement signals [has elements for processing]processes the measurement signals to provide the space-resolving measurement.

Description

Capacitive Magnetic Field Sensor

A plurality of magnetic field sensors is known, which are based on the Hall or magnetoresistive effect. These magnetic field sensors are extremely temperature dependent, and for this reason they are not well suited for high-precision applications or else require very expensive electronic or electrical temperature corrections.

Furthermore, capacitive sensors are customarily usued for measuring pressures or accelerations. These generally prove to be mechanically very stable and have small exterior dimensions.

It is the object of the invention to create a magnetic field sensor which depends less on interfering temperature effects.

According to the invention, this object is achieved by the characteristics specified in Claim 1.

The inventive capacitive magnetic field sensor has two electrodes, which are spaced apart from one another and which form a measurement capacitance. The first electrode is situated on a first substrate body, and the second electrode on a second substrate body. The second substrate body is designed as a deformable membrane in the vicinity of the second electrode, and has a magnetic body, which is rigidly connected to the membrane and to the second electrode. If the magnetic body is caused to change its position by an external magnetic field, this change of position is imparted to the membrane and to the second electrode through the rigid connection between the magnetic body, the membrane, and this second electrode. The distance between the two electrodes is thus changed, so that the measurement capacitance of the sensor

changes as a function of the external magnetic field. This yields a reliable measurement of the magnetic field strength through the change of the capacitive properties of the sensor. This type of structure of the magnetic field sensor significantly reduces its temperature dependence, since the elastic properties of the capacitive sensor here are much less subject to temperature dependencies than the prior art sensors based on the Hall or magnetoresistive effect. Furthermore, the inventive capacitive magnetic field sensor proves to be mechanically very stable, not prone to trouble, and also has small external dimensions.

Advantageous designs of the capacitive magnetic field sensor are presented in the subclaims. In particular, it proves to be especially advantageous to situate the second electrode and the magnetic body on different sides of the membrane. This excludes a mechanical or electrical direct effect of the magnetic body through the second electrode due to the membrane which separates them. Also, this advantageous arrangement also proves to make manufacture of the sensor much easier, since the two sides of the membrane can be subjected to different production processes, which cannot mutually influence or disturb one another through their mechanical separation by the membrane.

The production process for the capacitive magnetic field sensor is thus simplified and made economical.

The magnetic body advantageously is constructed as a thin, flat layer, whose surface is joined to the membrane. This surface connection produces a very rigid arrangement of a layer-like magnetic body, the membrane, and the second electrode. This rigid structure of the various materials markedly reduces the mechanical temperature dependence of the properties of the capacitive sensor.

Furthermore, this layer can be applied very easily in the manner of an electrochemical deposition process, comparable to the process for applying printed circuits to circuit boards. This makes it possible to produce a layer with a defined thickness very easily, and assures that a defined quantity of magnetic material is used for the magnetic body, a quantity which is sufficient to influence the position of the magnetic body adequately through the action of an external magnetic field and thus to determine the magnetic field strength. The use of ferromagnetic material has here proven to be especially beneficial. Such material can be applied very simply and securely by appropriately designing the deposition method.

According to a preferred embodiment of the capacitive magnetic field sensor, an electronic arrangement for processing the measurement signals is integrated into at least one of the substrate bodies. This integration takes the form of an integrated circuit. This assures that, in addition to the extremely compact structure of the capacitive sensor, an electronic very advantageous arrangement for evaluating the measurement signals is also present, which is especially characterized by low loss power in the path from the actual capacitive magnetic field sensor to the arrangement for processing the measurement signals and thereby also has an especially good signal-to-noise ratio, and thereby provides a very differentiated evaluation and representation of the magnetic field strength. This inventive capacitive magnetic field sensor thus proves to be an extremely compact and reliable magnetic field sensor with high resolution. Such sensors are especially important in the automobile industry, where very limited space is generally available.

The electronic arrangement for processing the measurement signal preferably is situated in the first substrate body below the

electrode that is affixed thereto. This structure in the mechanically rigid, immobile first substrate body also assures a mechanically trouble-free electronic arrangement for processing the measurement signals. This significantly extends the field of application of this capacitive magnetic field sensor, and makes it especially suitable for the automobile industry or the aircraft industry.

It is especially advantageous to divide the electronic arrangement for processing the measurement signals and to situate the parts separately in the two different substrate bodies. Here, too, the electronic arrangement preferably is designed in the manner of an integrated circuit. Through this division, electronic functional groups such as amplifiers, evaluation units, or control units can be electronically decoupled from one another, and thus a cross talk from one functional group to the other functional group can be prevented. Precisely in the case of very weak signals with especially poor signal-to-noise ratio, very accurate measurement results for the field strength nevertheless can be calculated and displayed, since now this arrangement for processing the measurement signals markedly reduces any impairment of the measurement results due to cross talk between amplification, evaluation, etc.

It has proven especially suitable to design the capacitive magnetic field sensor so that at least one of the electrodes is formed by conductor tracks on the respective substrate, which preferably are part of the electronic arrangement for processing the measurement signal. Through this design, the electrodes can be produced very simply, and their form and dimension can be specifically adapted to the particular requirements. This yields a very compact, very reliable, and high-resolution capacitive magnetic field sensor. When the conductor track

of the electronic arrangement is used both as electrode and as electronic element, it becomes possible to achieve a high degree of integration for the overall arrangement and to use this conductor track synergetically.

An especially advantageous capacitive magnetic field sensor has an electrode whose spatial structure makes it able to provide still more spatial resolution of the arrangement of the electrodes relative to one another, beyond their pure distance from one another. This makes it possible to show and make available to the user not only the pure magnetic field strength but also the orientation of the magnetic field or the time- or space-change of the magnetic field, by means of a space-resolving measurement. This aspect comes especially to bear when the two electrodes are not disposed parallel to one another through an external influence, e.g. the pattern of the magnetic field or the time- or space-change of the magnetic field, but rather are situated at an angle to one another and this angle changes through the flexible design of the membrane and/or the motion of the electrodes relative to one another. Such changes prove very useful to the user of the capacitive magnetic field sensor, since he obtains further information about the time or space behavior of the external magnetic field. Such information especially allows conclusions regarding the further actuation and/or amplification of the measurement signals. It has proven especially advantageous to dispose the electronic arrangement for the space-resolving processing of the measurement signals of the spatially structured electrode of the electronic arrangement for processing the measurement signals in one or in both substrates. Here, too, this arrangement proves to be especially advantageous both in terms of production engineering and as regards the compactness of the capacitive magnetic field sensor as well as regards its mechanical stability.

An embodiment of the invention is shown in the drawing and will be described in more detail below.

Figure 1 schematically shows the structure of the capacitive magnetic field sensor. The capacitive magnetic field sensor 1 has a first electrode 2, which is situated on a first substrate body 4. A second electrode 3 is associated with the first electrode 2, and is situated at a distance therefrom. It is affixed to a second substrate body 5. The second substrate body 2 [sic] is designed as a membrane in the vicinity of the second electrode 3. In this way, the distance between the two electrodes 2 and 3 can change under the action of a force on the membrane, more or less depending on the type and hardness of the membrane. In this capacitive magnetic field sensor, a magnetic body 6 is situated on the backside of the membrane, that is on the side which faces away from the second electrode 3. Depending on an external magnetic field, said magnetic body applies a defined force on the membrane and thus moves the membrane together with the second electrode 3, thereby changing the distance between the two electrodes 2 and 3. This change of distance causes a change in the capacitance of the arrangement consisting of the two electrodes 2 and 3. This change of capacitance is amplified and evaluated by an arrangement (not shown here) for processing the measurement signals in the first substrate 4. The inventively realized concept of the magnetic field sensor thus makes it possible to measure the field strength of the external magnetic field very reliably, without strong temperature dependencies.

List of Reference Symbols

1	Capacitive magnetic field sensor
2	First electrode
3	Second electrode
4	First substrate body
5	Second substrate body
6	Magnetic body

Claims

1. A capacitive sensor (1) with a first electrode (2) and a second electrode (3), which are spaced apart from one another and which form a measurement capacitance, such that the first electrode (2) is situated on a first substrate body (4) and the second electrode (3) on a second substrate body (5), and the second substrate body (5) is designed as a deformable membrane in the vicinity of the second electrode (3), characterized in that a magnetic body (6) is disposed in the vicinity of the second electrode (3) and the membrane, which magnetic body is connected to the membrane and to the second electrode (3) in such a way that a change of position of the magnetic body (6), induced by an external magnetic field, will cause a change of position of the second electrode (3) via the membrane, resulting in a capacitance change.

2. The capacitive sensor of Claim 1, characterized in that the second electrode (3) and the magnetic body (6) are situated on opposite sides of the membrane.

3. The capacitive sensor of one of the preceding claims, characterized in that the magnetic body (6) is formed as a thin layer.

4. The capacitive sensor of one of the preceding claims, characterized in that the magnetic body (6) contains ferromagnetic material.

5. The capacitive sensor of one of the preceding claims, characterized in that an electronic arrangement for processing the measurement signals is integrated into at least one of the substrate bodies (4, 5).

6. The capacitive sensor of Claim 5, characterized in that the electronic arrangement for processing the measurement signals is situated in the first substrate body below the electrode affixed thereon.

7. The capacitive sensor of Claim 5, characterized in that a first part of the electronic arrangement for processing the measurement signals is situated in the first substrate body (4) and a second part of the electronic arrangement for processing the measurement signals is situated in the second substrate body (5).

8. The capacitive sensor of one of the Claims 5 to 7, characterized in that the electronic arrangement for processing the measurement signals has elements to amplify the signal.

9. The capacitive sensor of one of the Claims 5 to 8, characterized in that the electronic arrangement for processing the measurement signals has elements for actuating the signal.

10. The capacitive sensor of one of the Claims 5 to 9, characterized in that at least one of the electrodes is formed as one or more conductor tracks.

11. The capacitive sensor of Claim 10, characterized in that the conductor track is part of the electronic arrangement for processing the measurement signals.

12. The capacitive sensor of one of the preceding claims, characterized in that at least one electrode (2, 3) has a spatial structure for a space-resolving measurement.

13. The capacitive sensor of Claim 12, characterized in that the electrode (2, 3) has mutually parallel, strip-shaped elements.

14. The capacitive sensor of Claim 12 or 13, characterized in that the electronic arrangement for processing the measurement signals has elements for processing the space-resolving measurement.

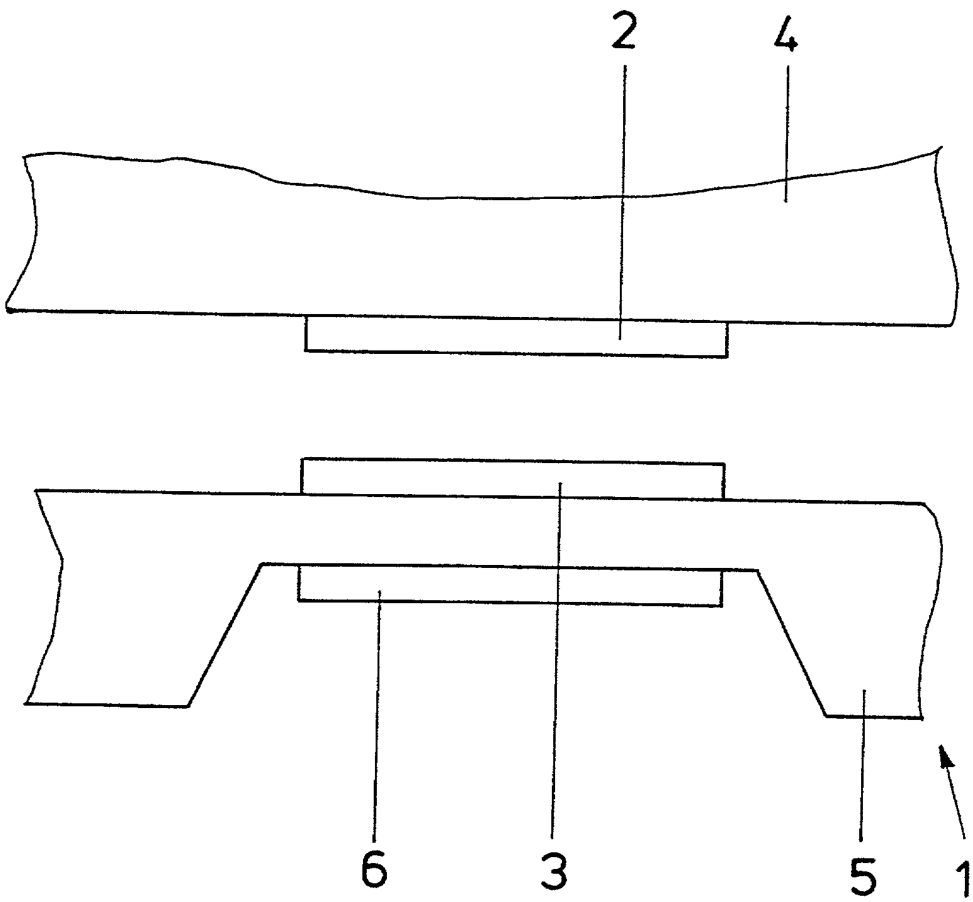
With International Search Report.
Before expiration of the time limit for modifications of the claims; publication will be repeated in case of modifications.

(54) Title: **CAPACITIVE MAGNETIC FIELD SENSOR**

(57) Abstract

The invention relates to a capacitive magnetic field sensor. This sensor has a first electrode (2) and a second electrode (3), which are spaced apart from one another and which form a measurement capacitance. The first electrode (2) is situated on a first substrate body (4), and the second electrode (3) on a second substrate body (5). The second substrate body (5) is designed as a deformable membrane in the vicinity of the second electrode (3). A magnetic body (6) is situated in the vicinity of the second electrode (3) and the membrane, and is rigidly connected to the membrane and to the second electrode (3). As a result of this rigid connection, the influence of an external magnetic field on the magnetic body causes not only the magnetic body (6) to change its position but also causes the membrane and the second electrode (3) to change their position, since they are rigidly connected to said magnetic body. Because the second electrode (3) changes its position, its distance from the first electrode (2) changes, and thus the measurement capacitance, which acts as a measure of the externally applied magnetic field. This capacitive magnetic field sensor is distinguished by very small exterior dimensions, great mechanical stability, and low temperature dependence.

FIG 1



Docket No: Mic.6287

DECLARATION AND POWER OF ATTORNEY

We, the below named inventors, hereby declare that:

Our residences, post office addresses, and citizenships are as stated below next to our respective names.

We believe we are the original, first, and joint inventors of the subject matter which is claimed and for which a patent is sought on the invention entitled **CAPACITIVE MAGNETIC FIELD SENSOR,** the specification of which was filed with the United States Patent and Trademark Office on June 19, 2001 and designated serial number 09/868,538.

We hereby state that we have reviewed and understand the contents of the above identified specification, including the claims.

We acknowledge the duty to disclose information which is material to patentability in accordance with Title 37, Code of Federal Regulations, Section 1.56.

We hereby claim foreign priority benefits under Title 35, United States Code §119(a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate filed by us on the same subject matter having a filing date before that of the application on which priority is claimed: International Application No. PCT/EP99/10045 filed December 17, 1999 and German Application No. 198 58 826.7 filed December 19, 1998.

We hereby declare that all statements are made hereby of our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

And we hereby appoint:

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all of the firm of Samuels, Gauthier & Stevens, our attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

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